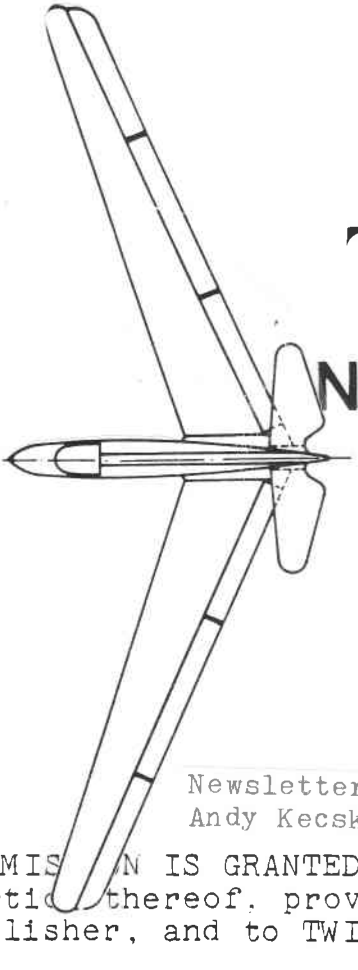
NO 26 AUGUST 1988

TWITT

NEWSLETTER



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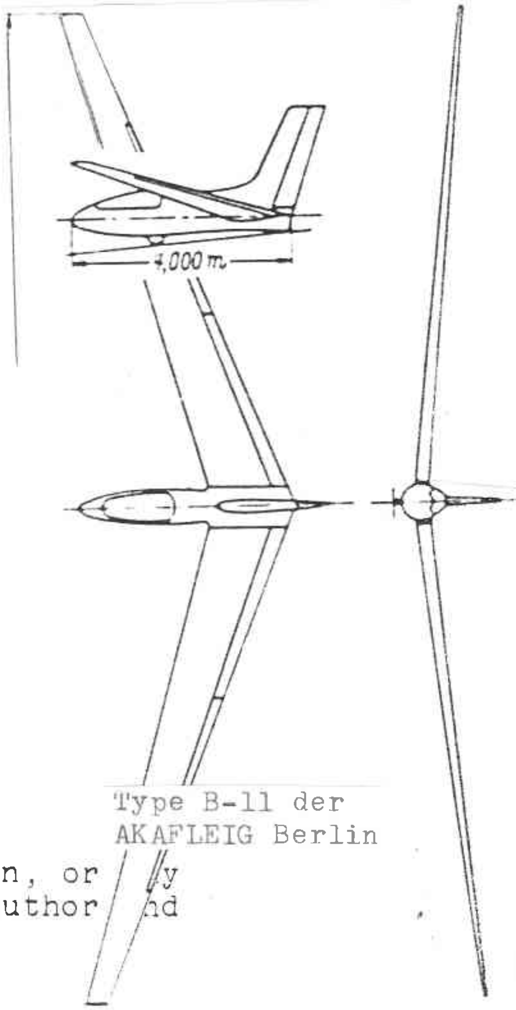
Andy Kecskes



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TWITT
(The Wing Is The Thing)
PO Box 20430
El Cajon, CA 92021

Movie- "The Impossible Takes A Little Longer" the story of the Convair Skate

The next TWITT meeting will take place Saturday 20 August 1988 at 1330 hours in Hangar A4, Gillespie Field, El Cajon, California.

MINUTES OF TWITT MEETING - JULY 16, 1988

The meeting was opened by Bob Fronius with an overview of the many items within the hanger, such as, the Lil Doggie, hang glider designed by Doug Fronius, LK recertified through the FAA using expoxy glues, Baby Bowlus wings, Baby Grunau wings (metric parent of the Bowlus wings), TG-2 fuselage and wings in restoration, and a pair of primary glider wings built by Louie Gonzalez back in the forties which are still airworthy.

Phillip Burgers gave a brief talk on his trip to Argentina, where he was to meet with Dr. Horten. Unfortunately, the mail system was not up to the task, since Dr. Horten did not get the letter and call Phillip until it was too late for the trip out to the Dr.'s home (about 800 kilometers outside of Buenos Aires).

Bob asked Phillip if he had heard anymore information on the Horten IV-C which had apparently been discovered. He had not, and Bob went on to explain that Ian Scott, of the Vintage Sailplane Museum, had come across the possibility of some plans or drawings of the IV-C in Argentina, and there were efforts underway to get them to the U.S.

Bob then ask Lee Hobby to show some slides of contest flying at Torrey Pines during the late fifties and early sixties. Included were several frames of the French Fauvel wing that eventually was bought by Jack Lambie.

Klaus Savier flew in from Orange county with some slides of his trip to Germany where he looked into the SB-13 development. The slides showed the wings still undergoing tuff testing and one had a fence installed due to an apparent spanwise flow problem. He commented that the winglets were molded into the wing with a large a radius junction, rather then just a right angle joint, to improve the blend of eliptical lift distributions coming off the wing and winglet. The winglet also had a noticeable amount of wash-in at the tips, which is a new concept in winglet design. The main wing also had about 2 degrees of negative incidence which worked its way out to zero at the wing tip, so it is effect the equivalent of having wash-in.

The fuselage pod had many unique control features, which made it a mechanical nightmare. The rudder peddles worked through a very complex set of telescoping supports, allowing a large amount of fore/aft adjustment. It all looked quite fancy, but obviously was heavy and expensive. They also had a drop test model of the pod for determining tumbling and occillation characteristics when the aircraft's recovery parachute system is deployed in flight. It was obvious they don't want to loose this advanced piece of design work.

In the hanger next to the SB-13 was a DG-300 17 meter carbon glider set up with a very complex wing-rake to measure drag. This is a project of the DFVLR (German equivilant to NASA) to determine the boundry layer turbulence from two different types of tapes. One has zigzags along the leading edge, while the other has dimples. The aerodynamicist responsible for the testing indicated the results were not yet conclusive, since control depended the location of the tape, with one having to be further forward than the other.

While in Hamburg, Klaus visited the University of Fine Arts. He talked with the designer of the Muscleair I & II, peddled powered aircraft that have out performed McCready's man-powered machines. This aerodynamicist is trying a new approach to a flying wing hang glider with the pilot within the wing, intergrated with the airframe, and a 50% chord flap. The flap will go out to about 60-65% span, along with elevator and aileron. The flaps deflect about negative 10 to 60-70 degrees positive, with an approximately 15 degree swept wing. The test model (hand launched) would fly long distances with a reflex or zero setting. Then when the flaps are put down about halfway the model glides in fully stable flight to a mid-point landing site. At full flaps the model lands very close to the launch point, again with very good stability. This is due to the flap's span, in effect, causing an aerodynamic twist of the wing, and therefore providing the stability. The concept is working in the model phase, but it was not certain how it will work in a full scale application.

Klaus went on to describe some of the techniques used in fabricating pieces for the Muscleair II. There was a 2-3 gram Kevlar shoe designed around a person's foot, which was then attached to the spoke mechanicism by a small tube in order to act as a peddle. The main frame for the aluminum spoke ring was again Kevlar sheet with small pieces of wood (like matchsticks) sandwiched in between to create a rib like structure for strength. The Muscleair II had a fully cantalevered wing span of about 75', and weighed approximately 65 pounds. It is still being flown, whereas, the Muscleair I is now on display in the Munich Aerospace Museum.

After a short break (boy does that hanger get hot in July), Bob introduced our main speaker, Kermit Van Every. (See last month's newsletter for his background info.) Since there was no viewgraph machine available he had to change the subject matter of his talk somewhat. Originally he was goint to discuss the history and development of airfoils, and then go into some theory and practical applications. However, he decided to pose a question to the group on the subject of confusion between critical Mach number and Mach number for drag divergence. Some experts will tell you these two are related, however, Mr. Van Every doesn't think this is necessarily true. If it were true we wouldn't have super critical technology or supercritical wings. His equation was Mcr ≠ Mdd (M critical ≠ M drag divergence or force divergence) and he felt these probably do not occur at the same time. For those who say this is true then Mdd = f(Mcr), but again he felt this was not true either.

Mr. Van Every then commented on how computers have eliminated the need for a lot of work in the area of compressability corrections; trying to correct low speed pressure distributions, therefore, low speed forces for compressability until something happened. He went on to plot the pressure coefficient versus free stream Mach number to determine the Mcr point. An anaylsis of experimental data shows the divergence and a drop in force characteristics maynot really take place until some point past the Mlocal = 1 (or Mcr). This is some ways substantiates that parts of the wing or airplane can exceed local Mach 1 without any adverse affects or knowing that you are partially supersonic. When you get to some point where you have a lot of supersonic flow you will get divergence, i.e. you either have a rapid rise in drag, or you can have a break in the moment curve, your control surfaces become ineffective or you just loose lift. But these things do not necessarily happen upon reaching Mcr. He feels this tends to disprove that Mcr and Mdd can be used interchangeably. He feels Mcr can be exceeded with the right technology and design of proper shapes. Specific proof can be found supercritical airfoils. Here you have a large amount of supersonic flow with some subsonic flow.

Mr. Van Every went on to plot lift and drag in the high speed ranges. Using zero lift coefficient, with drag staying essentially constant with Mach number up to the time you start to get drag rise. This drag increase reaches a peak which is the supersonic value. The Mcr could occur just about anywhere along the curve. Some of the first data to show this was the airfoil tests run by Dr. Goethert of the DVL in Cologne, Germany which came to our attention right after the war. He took a number of the NACA four and five digit airfoil thickness distributions and changed the geometery in various systematic manners. He found that Mcr sometimes occurs before the drag rise and at times after the rise. Another person working along this line was Pearcey of the National Physics Laboratory in Great Britain, where he developed the Peaky airfoils. These were a sort of an early supercritical airfoil, although without the degree of supersonic flow that the later Whitcomb airfoils had. All this was going on while we in the U.S. were still stuck with more conventional airfoils.

An interesting sidelight to airfoil history is that we are all familiar with the four and five digit airfoils which have a thickness distribution about like the Clark Y or German Goettingen 398. When they took out the camber and adjusted them to the same thickness you couldn't tell one from the other. This thickness distribution became the model for the NACA four and five digit airfoils. At that time it was very difficult to compute the pressure distribution over any arbitrary airfoil. However, eventually one of the NACA men, Theodore Theodorsen, came up with a scheme where you could calculate the pressure distribution over any airfoil if you specified the ordinates and it had a sharp trailing edge, and you met the Kutta condition where the flow comes off smoothly at the trailing edge. Putting this in todays high speed computer terms, it took two proficient calculator operators about one month to come up with a single incompressible pressure distribution, whereas it can now be done in less than a hour, depending on the computer's size and speed, and be either compressible or incompressible data.

He went on to talk about FLO 22, a analysis code developed by Jameson for calculating pressure distribution of a wing sticking out of a wall. The wall was representative of the fuselage which didn't give quite the right aspect ratio or the right induced drag. He noted there are some newer modifiied codes like FLO 22NM (which accounts for boundary layer) which are still in use today by NASA Ames and many smaller companies that are supported by NASA Ames. (Jameson is now up to FLO 57 which will give flow distribution or pressure distribution for an entire airplane.) FLO 22 or 22NM is a straight forward code that works well once some adjustments have been made for results achieved through wind tunnel tests. For example, you have to add some type of Mach number increment to allow for what the body generates because of the assumption of a wall in the code. This makes it a reasonably flexible code, although it does have some limitations.

One thing he wanted to caution about was that early supercritical airfoils were not that great. Although they tended to shift the drag rise curve over, some of them with blunt leading edges had a tendency to produce drag creep. At the lower speeds you could have losses while moving at higher speeds you could be making a gain. The supercritical wing can add an increment to the drag divergence of between .08 and .1, which is an appreciable amount. Comparing this to thickness ratio, a 1% change in thickness ratio might increase the drag rise Mach number .012 or so. A reduction in aspect ratio from 7 to 6 might reduce drag rise about Δ M=.01.

This is the type of problem the commercial aircraft firms are struggling against. They are always trying to push the drag rise out since they are almost always cruising up on the drag rise a little ways. Klaus asked what the Germans were doing with the Airbus wing to get better fuel economy. Mr. Van Every commented that is was his understanding the lastest versions of the Airbus are using a full supercritical airfoil. Boeing has not yet gone to the supercritical airfoil since there are some disadvantages in certain flight conditions, and they have not been forced to use the newer wing. He had asked Douglas why they used a supercritical wing on the C-17 prototype (tactical airlift aircraft for outsize cargo) while Boeing had opted not to on their competition bid aircraft. He didn't offer the answer to the question he posed to Douglas. He did think supercritical airfoils are going to be used more in the future. Hernan mentioned that Boeing used a much higher sweep angle for their wings to help push the drag rise out but this also increases possible handling characteristics. The question was asked about whether the new airfoils must maintain its shape better than conventional airfoils therefore raising the manufacturing costs due to construction constraints in achieving this goal. Mr. Van Every thought we were in the process of a change in construction. He had planned to address this subject in his expanded version of the presentation, but did comment on the use of perhaps using composite structures to reach the desired goals in drag rise and laminar flow. However, NASA has determined that for smaller aircraft (general aviation, business jets, etc.) there is no reason why you shouldn't strive to get laminer flow across the surfaces. Many of these types of aircraft are being developed through increased use of composite materials.

Bild 16. Windkanalmodell des Projektes B 11 der Akaflieg Berlin von 2 m Spannweite

Ralph Wilcox asked about the shape of these airfoils. Mr. Van Every explained they tended to be flatter, haave a large nose radius, and then get the lift back by using a fairly heavy cusp at the trailing edge. He agreed with Hernan's comment on the fact that they work well at design CL, but they start deteriating rapidly if they fly at lower altitudes or excessively high altitudes. When the lift coefficient is too low or too high you can get pressure shock (lower or higher surface). Ralph commented that early Boeings had the flatter tops on the inboard sections to prevent tuck-under. Mr. Van Every indicated this may have been to control tuck-under, or to just get more volume for wheels, fuel, etc.

Mr. Van Every offered to come back another time to go into this area in more detail using the view graphs, which was eagerly accepted by the group.

Bob then put on a tape of a Japanese college students competing in a contest of glider and man powered ultra-ultra lights. It is quite entertaining to see the ingenuity of design that often only ended in a short fall to the water after launch from a platform. After the film, Bob commented on TWITT perhaps sponsoring a similar contest in the future where the aircraft would be limited to only flying wings.

With that the meeting was adjourned.

AUGUST'S SPEAKER

Bradford W. Powers

This will be Mr. Powers second appearance with TWITT, having given a presentation on the concept of dynamic similitude at the June 1987 meeting. Mr. Powers, a former Convair engineer, worked with dynamic models of flying boats, and has written several articles for model magazines. At the August meeting he will be discussng weight and balance as the problems relate to scaling up from models to full size aircraft. He will also be showing a film on the Convair Skate, an jet fighter designed to operate from the water, and discuss some of the design features and their inherent problems.

TWITT NOTES

RAFFLE: C.M. Nicholson won the multi-outlet extension cord raffle prize. He then donated it back to TWITT for next month's drawing.

DUE DATE: Due date for the September Newsletter will be September 7. If possible, please get your information in earlier so the editor can plan spacing.

MAILING: The numbers on your mailing label indicate when your mailing fees expire. For those listed below this will be your last newsletter until receipt of your $15 or more contribution towards administrative, printing and mailing costs. Contact June Wiberg at the meeting or send it in so you can continue to get this valuable information.

Robert Hoppe
Duane Renken
Klaus Savier

MEETINGS: The Sailplane Home Builders Association will hold their Western Workshop at Tehachapi, Calif., on September 2-5 (LaborDay weekend). Contact Jim Mills (805) 669-8944. There will be a lot of homebuilts as well as factory ships.

WINGS FOR SALE

Horten HIV Flying Wing. Incomplete original drawings on 18" x 24" blueline, 21 sheets. $25 per page. Airfoil coordinates, 44 pages, $10 pp. Manuscript, 223 pages, $50 pp. Write: Flight Engineering & Development, P.O. Box 667, Dallas, GA 30132

Marske Pioneer Model P-11-C kit. Have plans, fuselage and metal parts. Kits with all welding completed. Rudder and skid complete and installed. Also hve landing gear, tow hooks and leading edge wing ribs. Well over $3000 worth of parts all for $1000. Reason for sale: I have two kits and only plan to build one ship. Call Lew Johnson, (301) 495-5757

Marske Pioneer Project Wing, ready to assemble. Fiberglass fuselage and enough wood to finish. $1500 Call: (216) 234-2069 OH

OFFICE HOURS

OPEN Most days about 9 or 10
Occasionally as early as 7, But SOMEDAYS
as late as 12 or 1.

WE CLOSE about 5:30 or 6
Occasionally about 4 or 5, But
Sometimes as late as 11 or 12.

SOMEDAYS or afternoons, we
aren't here at all and Lately
I've been here just about all the time,
Except when I'm someplace else.

SWEPT-WING CONFIGURATIONS

Theories and Comments

By JOHN RAPILLO. . .In this first of two parts examination of the swept-wing configuration, is an aeronautical engineer and model builder who has devoted his life to aviation pursuits. Here he discusses the basics.

- *The author, John Rapillo, has had a long and varied association with aircraft, both model and full-size, including free flight, indoor, and radio-controlled models, and has served as a judge in Scale Masters' competitions. He is retired from Douglas Aircraft, where he spent 41 years in various capacities as an engineer and in management. Today he is part-owner of Lancer Engineering, which provides general aviation airplane design and modification services. John flies the company Beechcraft Bonanza A36 almost daily, and he is an instrument and multi-engine-rated commercial pilot. Presently he is completing a two-place homebuilt aircraft of his own design. It seems redundant to add John's final comment: "All of my career has been associated with and dedicated to aviation and things aeronautical."*

The Forward-Swept Wing (FSW) model design, construction, and flight articles which appeared recently in the December 1987 issue of *Flying Models* by Dick Sarpolus and similarly, the two articles by Don Sobbe in the February and March 1987 issues of *R/C Modeler*, are very notable and commendable approaches to a rather unique phase of model design and R/C flying. It is interesting to note the somewhat successful results achieved by both builders during the initial experiments with this configured wing concept, and particularly the maneuvering performance in the high angle of attack modes exhibited by Don Sobbe's FSW-3 R/C model during flights as outlined in his articles.

The related experiences of further flight testing of Don Sobbe's FSW model disclose many benefits in the handling characteristics of the forward-swept wing planform that we, as modelers, are seldom made aware of or become knowledgeable of other than the conventional designed airplane we have long accepted as the "standard." The above articles prompted the opportunity to present the basic precepts involved, and to provide an understanding and appreciation of the complexities associated with swept wing design. Hopefully, this text will assist those modelers and readers who want primarily to gain insight into the model design process involved, and to expand and help promote their interests towards developing the new generation of swept-wing modeling.

Modern text book principles regarding forward and aft swept-wing planforms relate some interesting and enlightening evaluations on the hows and whys of this subject matter, and for what it's worth an analysis of swept wing configurations is noteworthy of mention. Use of technical terms and formulas are omitted, but rather, illustrations are presented quite generally to facilitate understanding.

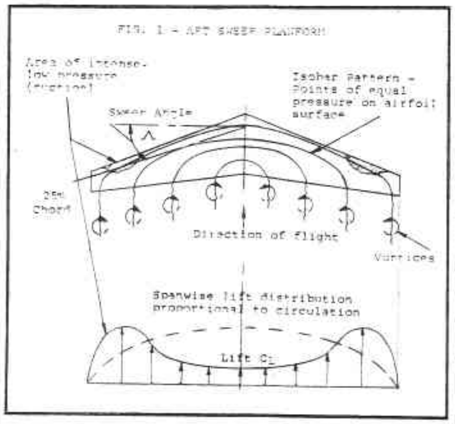


FIG. 1 - AFT SWEEP PLANFORM

Aft sweep causes inboard vortices to trail ahead of outboard vortices, creating up-wash toward tips; angle of attack and lift coefficient(C_L) of outboard sections is increased causing tips to stall first.

Material presented for this article is a compilation of data and information excerpted from many excellent technical books and texts which are listed as acknowledgements at the close of the article.

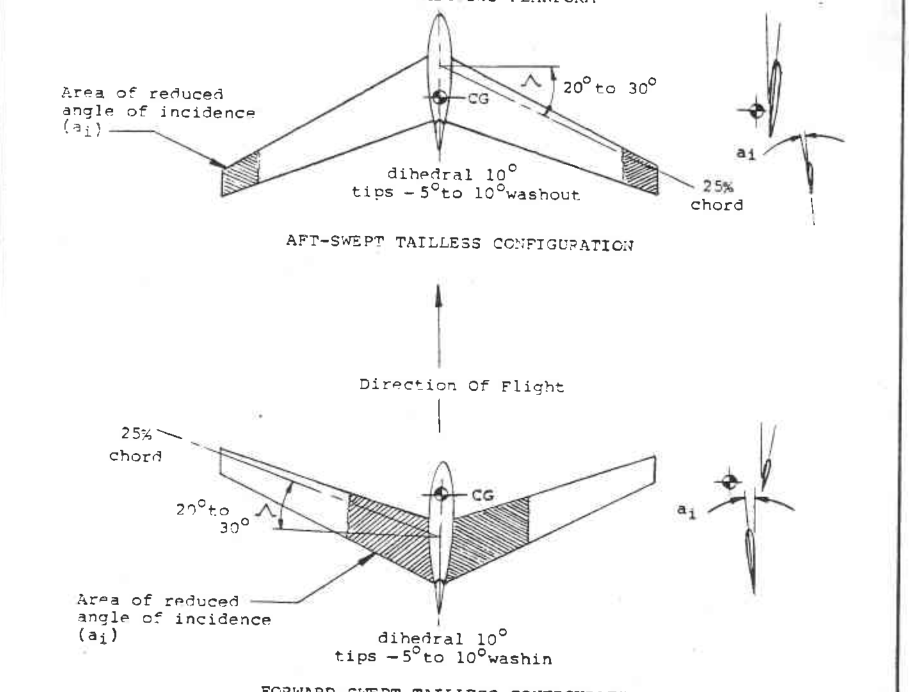
AFT-SWEPT WING

Aft-swept wings are designed primarily to: Arrange the CG of the airplane and the Aerodynamic Center (AC) of the wing to coincide more closely, improve high speed characteristics on full-size high-performance airplanes by delaying compressibility effects, and provide directional and longitudinal stability of tailless airplanes (configurations with no separate stabilizer).

There are some disadvantages of an aft-swept wing planform, particularly when positioned at an increased angle of attack and reduced airspeed. Wing boundary layers tend to move outboard, assisted by the spanwise airflow component causing them to separate prematurely at the tips. Also, wing sweep staggers the vortices trailing across the span so that those vortices trailing inboard are ahead of those trailing further outboard (See Fig. 1). This results in early wing tip stalls (before the root stalls) while the root, which is ahead of the CG, continues to lift. Effectively, this is followed by pitch up, forcing a full stall, rapid drag rise, and potential pitch/roll/yaw diver-

TAILLESS AIRCRAFT WING CONFIGURATIONS

FIG. 2 - TAILLESS PLANFORM



FORWARD-SWEPT TAILLESS CONFIGURATION

Forward-swept tailless configuration.

gence. On full-scale aircraft, a degradation of control effectiveness and/or control reversal may occur. Additionally, if geometric sweep angle at the leading edge is excessive, this may cause the wing to twist (aeroelasticity) under aerodynamic loading, thus reducing the angle of attack at the tips (Refer to section on Forward-Swept Wing).

Flow characteristics shown in Fig. 1 are approximate pattern lines on the upper surface with wings at an angle of attack α of approximately 21 degrees; a positive sweep angle Λ of 45 degrees; and an aspect ratio (A) of 6.

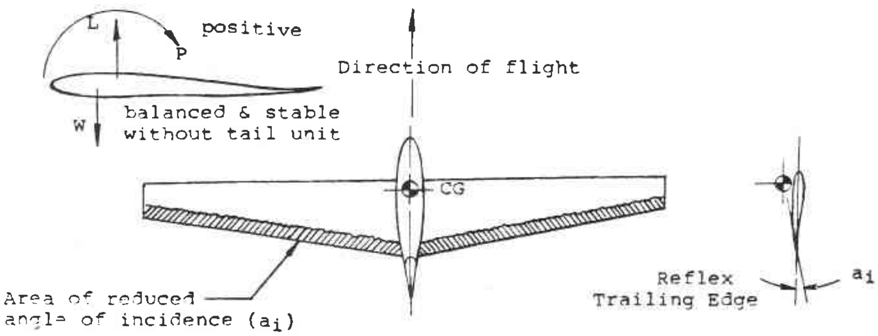
Swept-wing theory is based on the principle that the velocities which generate the lift and drag forces are produced by the component perpendicular to the leading edge, or more specifically, to the 25-percent chord line of the wing. It is reasoned that by changing the sweep of the wing the relationship between the speed of the aircraft and the wing velocity can be changed. The principle is to place the aircraft in the transonic range and have its wing think it is back in the subsonic region.

The inboard regions of the aft-swept wing are much closer to the nose of the aircraft than are the tips, and as the airplane continues to develop lift "up front" after the aft end (that portion further from the nose) ceases to "cooperate," the aircraft is likely to nose up and approach a stall. Now, because of the complexities surrounding aircraft design and all that which is associated with aviation-related development, we resort to the "compromises" made available and essential to resolve and/or alleviate such conceptual design barricades. Enter the devices, such as wash out of the tip, slats, wing fences, vortex generators, Kruger flapped, drooped leading edges, and outboard leading edge extensions, all of which serve to reduce the cross-flow and delay pitch up—the sudden and dangerous nose up movement.

Modelers delving into scale model swept-wing jet aircraft designs may find similar devices essential to the stability and controllability of the model, which undoubtedly will provide more docile performance during the high angle of attack and flare out during landing modes.

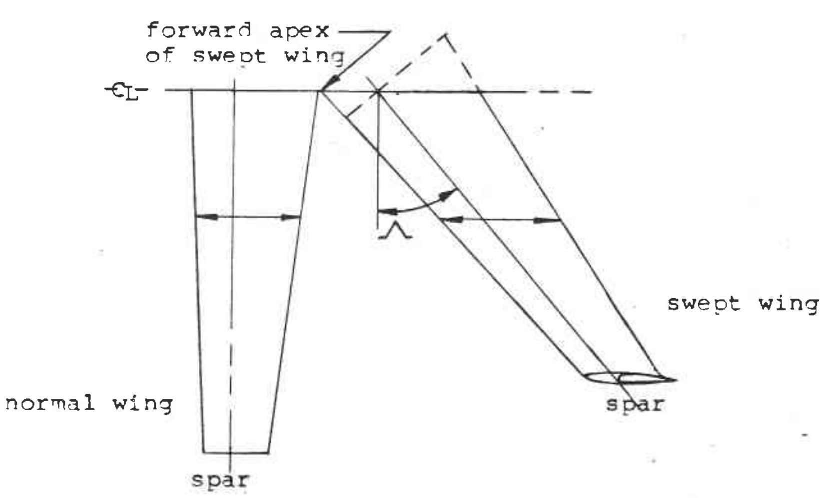
For the most part, shallow portions of sweep-back or sweep-forward do not significantly affect the lift distribution. For most models there is minimal benefit derived from such wing planforms. As mentioned earlier, in full-scale aircraft a principle design practice applying wing sweep is for the purpose of balance and stability.

FIG. 3 - REFLEX WING TAILLESS PLANFORM



Reflex wing tailless planform.

FIG. 4 - SWEPT WING FOR HIGH SPEED



The aerodynamic chord of a wing is lengthened as shown by projection and the airfoil section is given greater fineness(chord length/maximum thickness) by sweep reducing geometrically the thickness/chord. Maximum chord thickness lies along the spar line.

This is the reason why tailless aircraft have generous sweep-back and/or sweep-forward wing planforms (see Fig. 2).

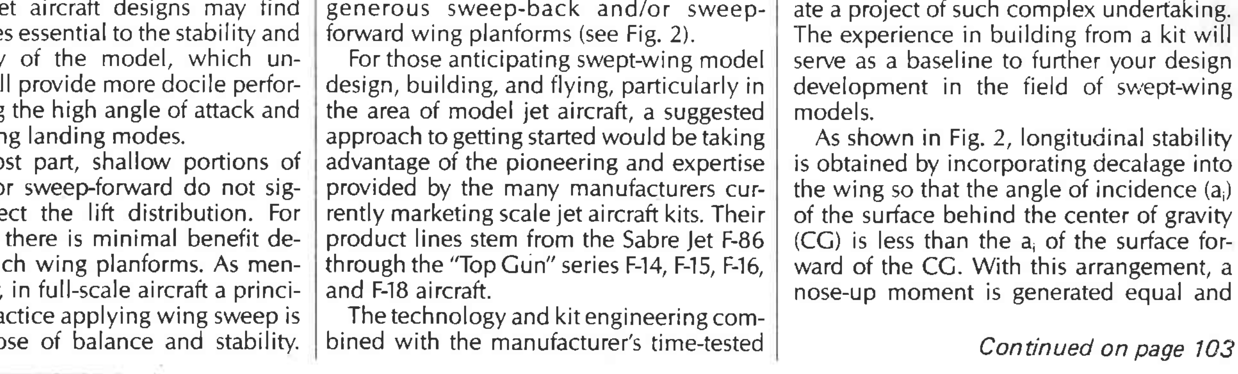
For those anticipating swept-wing model design, building, and flying, particularly in the area of model jet aircraft, a suggested approach to getting started would be taking advantage of the pioneering and expertise provided by the many manufacturers currently marketing scale jet aircraft kits. Their product lines stem from the Sabre Jet F-86 through the "Top Gun" series F-14, F-15, F-16, and F-18 aircraft.

The technology and kit engineering combined with the manufacturer's time-tested flying, hardly makes it worthwhile to initiate a project of such complex undertaking. The experience in building from a kit will serve as a baseline to further your design development in the field of swept-wing models.

As shown in Fig. 2, longitudinal stability is obtained by incorporating decalage into the wing so that the angle of incidence (a_i) of the surface behind the center of gravity (CG) is less than the a_i of the surface forward of the CG. With this arrangement, a nose-up moment is generated equal and

Continued on page 103

FIG. 5 - THE BUZZARD



opposite to the normal nose-down pitching moment.

Some studies and works by well-known scientists and design experts show that tailless aircraft do not necessarily need sweep (see Fig. 3).

A reflex trailing edge incorporated in a section of the wing can provide an unswept wing with stable characteristics. However, the CG position of an unswept tailless wing is limited in range. In essence, wing sweep, which effectively increases the chord of the wing, provides more margin for mis-loading (see Fig. 4). However, when the trailing edge is reversed, as shown in Fig. 3, the center of pressure moves to the rear if the angle of the wing increases, thereby tending to reduce the flying angle and return the wing to its normal flight position.

Planform arrangement shown in Fig. 3 lends itself favorably to R/C slope soaring models with resulting exceptional flying qualities, providing the CG is properly positioned and aggressive efforts towards finite flight trimming is achieved. The reflex portion of the wing trailing edge can incorporate elevon application for lateral and longitudinal control effectiveness.

In support of the reflex wing tailless concept, there are a number of model plans and kits in free flight and R/C designs available through most model aircraft publications. Successful models such as: The Gryphon, by Ron Neal; The Windfreak, by Roger Sanders; and The Raven, by Dave Jones are a few of the more popular designs which offer combinations of aerobatics and slope soaring qualities.

Again, various planform designs are compromises, and performance considerations are equally varied. A tailless airplane relying singularly on the qualities of a straight wing can be extremely sensitive, to the point of producing a less than required amount of damping about the lateral axis. In contrast, a swept wing, having a longer length between the forward apex and the aft end of the lateral edges, would, therefore, be more acceptable using the wing tips for stabilization and control. Considering the areas near the tips as a pair of horizontal tail surfaces, we conclude a configuration which is basically similar to the conventional wing with a tail arrangement. To enhance directional stability and control, the wing tips can be designed to include a pair of vertical fins.

Early British developments with similar parameters produced the "Pterodactyl," and several similar successful aircraft and gliders were designed and built by Dr. Ing. Alexander M. Lippisch.

The forward-swept, or "Buzzard Wing" as it is sometimes referred to, is really a borrowed principle which has long been provided by Mother Nature's wing planform for soaring birds—such as buzzards

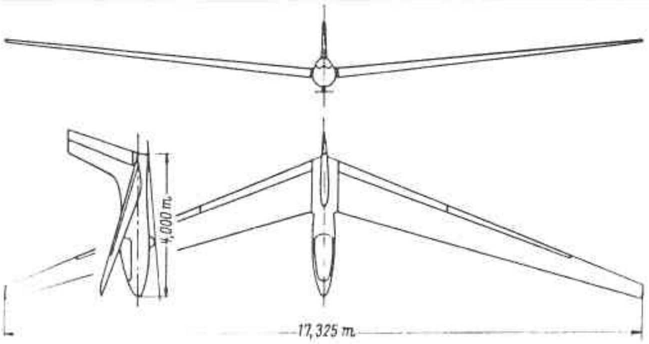


Bild 17. Entwurfsskizze eines Segelflugzeuges mit Vorpfeilung in Nurflügelbauweise (Typenbezeichnung B 11 der Akaflieg Berlin)

Entwurfsdaten:	Flügelfläche	15,8 m^2
	Spannweite	17,3 m
	Zuspitzung	0,25
	Pfeilung der 25 %-Linie	18°
	max. Fluggewicht	321 kp
	Landegeschwindigkeit bei G_{max}	63 km/h
	opt. Gleitgeschwindigkeit bei G_{max}	80 km/h
	zul. Höchstgeschwindigkeit	155 km/h

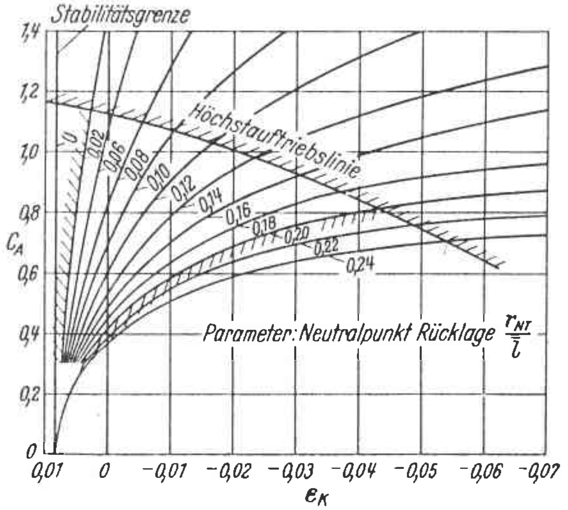


Bild 18. Auftriebsbeiwert der Gleichgewichtsgeschwindigkeit in Abhängigkeit vom Klappenwinkel bei verschiedenen Neutralpunktsrücklagen

Soaring birds, such as buzzards, retain their wings motionless with an average sweep forward of the tips from approximately 10 to 20 degrees ⋏ sweep angle. For the approach-to-landing phase, when highest possible lift is required, birds place their wing tips even further forward which results in an extreme forward sweep angle. Because nature appropriates the simplest and most effective "design concept," this function for increasing lift can be accepted as ideal. If a more effective measure could be made applicable, as increasing wing camber for example, nature would undoubtedly have provided that concept.

Next month the author delves deeper into the theory of swept-wing aircraft, including the Grumman X-29A, the advantages of aft-swept vs. forward-swept wings, and tailless model gliders. •

Theories and Comments

By JOHN RAPILLO. . .In the final part of his two-part series on forward-swept wings, the author explains the concept of forward-swept vs. aft-swept wings, and examines the Grumman X-29A .

- Theories, studies, and experiments in modeling tailless glider designs through the years has progressed to the present with more than just cut and try methods (refer to Fig. 2). In discussing the forward-swept wing, model designers and builders provide instructive examples and design parameters of their findings and suggestions. Among some reports of tailless and all-wing glider (soaring types included) models, wing designs with aspect ratios from 1:6 to 1:9 are considered as most advantageous, and a wing taper ratio (from root to tip chord) of 2:1. Forward sweep angles from 15 to 20 degrees and dihedral set at approximately 8 to 10 percent of the wing span. Airfoil sections of symmetrical shape and 12-percent thickness prove adequate with a wing washin of approximately 3 degrees at the inboard section and the greater washin angle of incidence at the tip extremities.

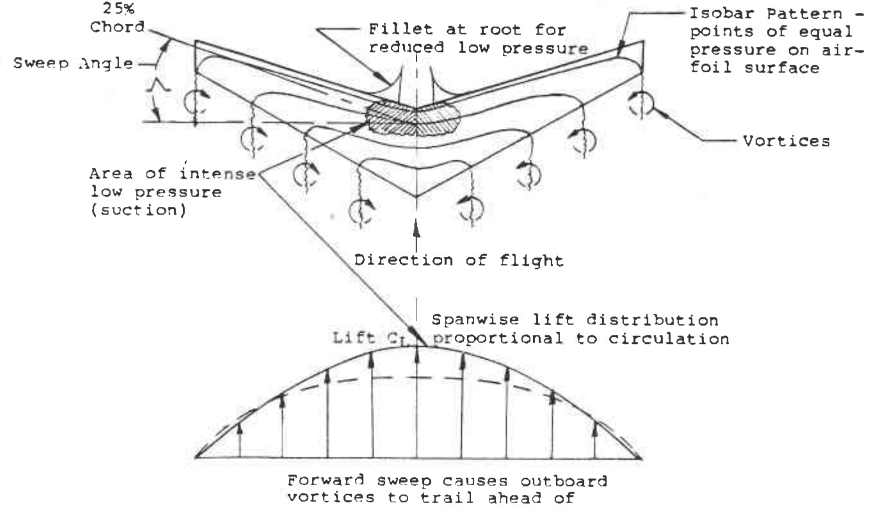
The most promising results, with regard to designing and building an R/C forward-swept wing model, lie within the scope and applied efforts exercised by the builder. Here then, is a workable baseline that can be used for a starter project which allows latitude for experimenting and modification with some reservations in keeping with known design rules and boundaries. Begin by using the above parameters for your initial layouts, and expand on your designing, building, and flying progressively.

Forward-swept wings work somewhat opposite for aft-swept wing in that it functions to assist low speed control. The forward-swept wing avoids premature tip stall because the root section stalls first and ailerons tend to remain effective well into the stall mode, however, pitch up still occurs. Because the swept-forward wings stall near their center sections first, the characteristic is desirable from control considerations as the outboard sections are free from separation and the lateral controls remain effective. It follows then, that lateral stability and control can be retained with forward-swept wing planforms. Conversely, forward sweep has an adverse effect on directional stability and, as such, a larger fin area is required for this configured wing design.

In considering the usable operating lift coefficient (C_L) of a swept-wing, tip stalling is generally the major factor as this leads to the unstable pitch-up moment. The combination of aspect ratio and sweep angle influence the stall and thus the moment (see Fig. 6).

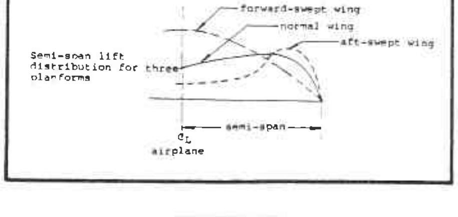
On full-scale aircraft, forward-swept wings, while aerodynamically advantageous, is considered structurally objectionable in some planform designs. This is because wing deflections produce increased angle of attack, which increases lift and further increases deflections (structural divergence). This combination is classed as being aero-elastically unstable beyond some critical speed (high Mach numbers), and the critical speed (M_{crit}) may be restricted to a lower speed envelope unless the wing is exceptionally rigid. The aerodynamic natures of the forward-swept wing renders it prone to structural divergence because as dynamic pressures increase, forces tend to deflect the leading edge upward. If a divergent speed were reached, a cycle of leading edge bending, increased angle of attack, and increased wing loading progresses to cause and result in structural failure. Thus, it can be asserted that wing design requires a high margin of structural integrity and rigidity to prevent and overcome divergence.

FIG. 6 - FORWARD SWEEP PLANFORM



Reverting to the R/C model with a forward-swept planform, structural integrity should be a prime consideration during wing construction, and the wing twist faction should be incorporated during the construction stage. Obviously, a model of three- to four-foot span does not incur strong aerodynamic wing loads or extreme performance speeds, so wing structure need be only reasonably conventional. However, designing for an eight-foot or longer wing span will require a more rigid structure to avoid the inevitable torsional (twist moments) loads which become magnified with intensity as speed is increased.

FIG. 7 - COMPARISON OF LIFT COEFFICIENTS
(exaggerated for clarity)



There is a significant advantage offered by the forward-swept wing arrangement when considering the design of the wing structure. The wing root area with its deep chord section provides for a very rigid construction, and also allows the root juncture assembly to be located further aft, behind the center of gravity (CG). It may also be possible to derive a lighter spar structure as a result of this planform arrangement, but this presumption may have different consequences depending on the builder's ability to construct "with lightness in mind" as a prime concern.

Continuing with baseline principles, a key element is the selection of a suitable wing airfoil section. As mentioned earlier, an appropriate wing section to start with would be a semi-symmetrical airfoil of 12-percent chord thickness, and this includes the modern NACA five- and six-digit series of laminar flow airfoils. These particular sections were developed to achieve natural flow in flight and produce significant drag reduction. These sections are: NACA 63_1-012; NACA 63_1-212; NACA 63_1-412; NACA 64_1-212; NACA 64-$_1$-A212; NACA 65_1-212; and NACA 65_1-412. Noted sections have maximum lift coefficients (C_{Lmax}) in the order of 1.6 for a plain airfoil, and approximately 2.5 with flaps. These coefficients are measured at a Reynolds number of 6 million.

In using this type of airfoil during wing construction and final assembly, particular attention towards maintaining a constant airfoil shape throughout is critical to the efficiency and performance characteristics of the laminar flow airfoil section. Consider that, when striving to lower the section drag, the closer must be the attention to maintaining both profile and surface finish.

Why a forward-swept wing and what advantage does it offer over the normal or the aft-swept wing? Substantiations favoring the forward-swept wing are:

1. The wing tips are relieved of static stress on the wing structure because lift generation is higher at the center section (see Fig. 7). This produces the same effect as washout on a normal straight wing.
2. The effects of a forward-swept planform produce very favorable spiral (diving) and lateral (yawing) characteristics.
3. Wing washout is not required and thus is eliminated by the use of this planform.
4. Because the forward-swept wing retains lateral stability and control, adding washin to the tip regions will generate an optimum overall lift effect.
5. Longitudinal stability is increased by both forward- and aft-swept wing planforms in that, the angular difference between wing and stabilizer incidence (also referred to as, "decalage," and/or longitudinal dihedral) is smaller. In essence, the overall wing lift produced at various angles of attack is somewhat levelled out.
6. As a result of less sensitive angle of attack changes, stabilizer areas can be reduced, or alternatively, a reduced length tail moment arm can be implemented.
7. Wing sweep also transposes spanwise lift distribution.

As shown in Fig. 7, note the manner in which taper causes section lift coefficients to peak towards an early stall. Reduced Reynolds number towards the tip would worsen the condition. Washout towards the tip on the aft-swept wing planform would reduce the incidence and lift coefficient beneficially. (Refer to Figure 1.)

BACKGROUND—FORWARD-SWEPT WING (FSW) CONCEPT

The forward-swept wing (FSW) concept is not new, as the aerodynamic advantages of forward-swept wings were recognized and developed during WWII. The JU-287 German bomber was in its development stages when Germany collapsed, but was further improved and placed into production by the Soviet Union later on. Another German project was the Blohm and Voss BVP 209 fighter with a 26.5-foot span which employed a pronounced forward-swept wing planform. However, this project never proceeded beyond the design stage. There were a number of German designed and developed high-performance sailplanes which included the FSW concept. Another design which incorporated the FSW planform was the American experimental ultrasonic Convair XB-53 aircraft. This particular project incorporated a pronounced sweep forward, short span, and stubby wings to attain ultrasonic speeds.

Since then, FSW research and development has progressed to the present state of the art, and the improvements in design concepts, techniques, and government program funding collectively have brought about the newest derivative of experimental projects, the Grumman X-29A Forward-Swept Wing demonstrator (see Fig. 8).

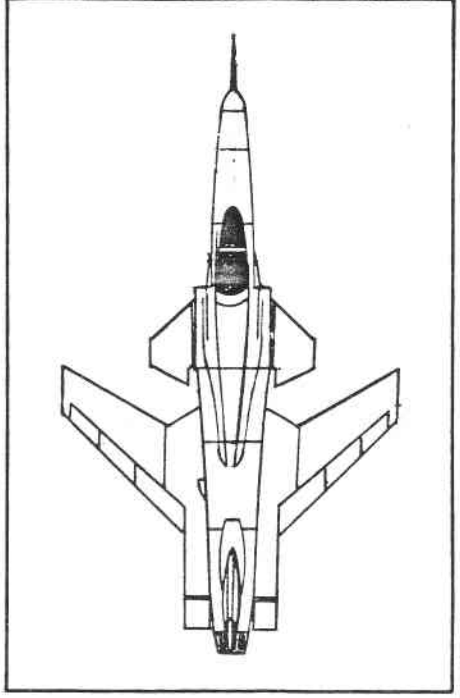


Fig. 8--Planform of the Grumman X-29A.

FSW design offers the promise of a new generation of tactical aircraft that will be lighter in weight, smaller in size, more cost effective, and more efficient than contemporary fighters. The advantages include improved maneuverability with virtually spin-proof characteristics, better low-speed handling, and reduced stalling speeds. Additionally, such designed aircraft have the advantage of lower drag across the entire operational envelope, particularly at speeds approaching Mach 1. Effectively, this permits the use of a less-powerful engine.

In the roll of a hi-tech prototype article and test-bed for Air Force and Navy advanced tactical fighter aircraft (ATF and ATA) programs, the X-29 represents combined aerodynamic features which include close-coupled canards, variable camber wing trailing edges, rear strake flaps, and digital fly-by-wire control system with an analog back-up computer to update positions of the control surfaces.

A significant design goal of the X-29 is to provide a 20-percent drag improvement over aft-swept wing aircraft. To date, the X-29 has been flown to Mach 1.4 speed, reached 5.3_g, and flown up to 20-degree angle of attach. A second angle of attack program is planned this year using a No. 2 X-29A aircraft.

General dimensions for the X-29A full-scale aircraft are presented for those whose interests lie with scale ducted fan R/C projects

WINGS

Airfoil: Supercritical wing section.

Thickness/Chord Ratio: Root—6.2 percent; Tip—4.9 percent.

No dihedral.

Incidence: -6 degrees at wing station 20 to +0.8 degrees at wing station 163.22.

Forward Sweep at 25-percent quarter chord: 33 degrees-44 feet.

Span: 27 feet, 2.5 inches.

Chord: Root—9 feet, 8.5 inches; Tip—3 feet, 11 inches.

Area: 188.84 sq. ft.

Aspect Ratio: 4.

FOREPLANES

All-moving canard surfaces.

Continued on page 91

FIG. 9 - STABILITY - FSW PLANFORM

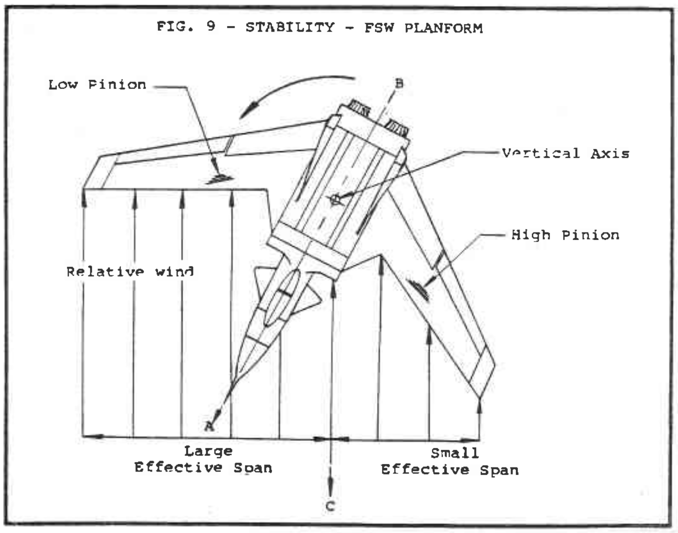
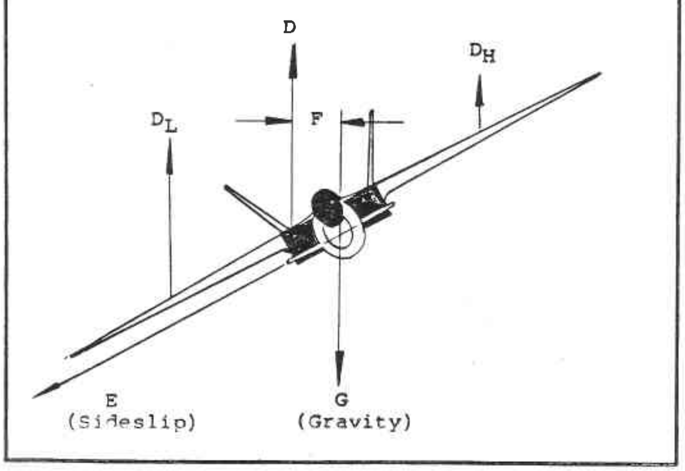


FIG. 10 - STABILITY - RIGHTING FORCES



Span: 13 feet, 7.5 inches.

Area: 35.96 sq. ft.

FUSELAGE

Overall length, including nose probe: 53 feet, 11.25 inches.

Height: 14 feet, 3.5 inches.

(*) Note: It has been reported that a German modeler who produces, among other scale R/C jets, an impressive model of the X-29 FSW with a wing span of 51 inches, fuselage length of 90 inches, and a flying weight of 12 pounds. The modeler, Mr. Herbert Koudelka, can be contacted by writing to his address: 18 Stauffenbergstrasse, 6050 Offenbach/Main, Federal Republic of Germany.

Referring to Fig. 6 and the general comments relating to lateral stability necessitates some explanation to describe the effects of lateral stability on forward-swept planforms. Using a hypothetical futuristic FSW concept for our model, let's review some factors and examples (see Fig. 9).

As shown in Fig. 10, the airplane sideslips (E) due to the gravity force (G), but also moves forward because of thrust power (propeller or ducted fan unit). As a result of this combination of motion, the airplane actually moves in the direction indicated by arrow (C). The volume of air (relative wind) striking the low pinion is proportional to the "large effective span" area. Conversely, the air stream width striking the high pinion is a lesser volume, as indicated by the "small effective span" area. Accordingly, air action on the low pinion causes much greater lift than on the high pinion.

As lift on the lowered wing increases and contrarily decreases on the higher wing, the airplane rotates about its longitudinal axis (AB) back to the normal position. The resultant lift (D) of both pinions acts upward on the lower pinion (whose lift action is identified as *DMIS*MIE*) because this pinion has more lift.

Correspondingly, the two forces, D and G, team up to from a "righting" couple (F), rotating the airplane back to flight position; reason being, that the forces D and G are opposites in their action, and as such, do not act at the same point. The farther apart these two forces are, the more powerful is the righting tendency.

In conjunction with the above, it can be added that forward-swept wings embody satisfactory directional stability and consequently produces sufficient turning and circling flight characteristics. For R/C models, forward-swept wings provide effective turnability, and it may be that the FSW planform does have significant influence in the "righting" and stabilizing effects of the model during takeoff and landing modes while flying in stronger winds and gusting conditions.

To summarize, the above information is basic in nature and provides only a general substance for the familiarization with swept-wing design as reflected by full-scale aircraft. Many illustrations and the technical explanations presented here are condensed outlines of sections taken from references noted below.

For models, appropriate design parameters, at best, are usually experimental approaches bordering success, but realistically, a great deal of study, evaluation, preliminary design, and comparison reviews of existing model concepts are required principles to resolve a workable and satisfactory project. When beginning a design, it is important not to become content with early three-view sketches and layouts; make numerous sketches and brainstorm all the ideas you can muster. You'll know when the final design can be "frozen" and preparations for cutting wood are at hand.

In the final analysis, your completed design will have consumed an exorbitant amount of your time and best efforts in producing the ultimate flying machine, so your achievement is most worthy of your pride and strong sense of accomplishment—after all, you created it.

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The 50 year old midget sail-plane "Lil Dogie"- Screaming Weiner. Owned by Bob Fronius on the left, being flown by Hernan Posnansky, Hemet, Ca.

OUR COVER STORY
THE FLYING PLANK

One of the most important ingredients in keeping any air museum moving ahead is the acquisition of a new airplane. First it provides added reasons to find the ways and means to expand such a museum. In addition it develops remewed interest and support throughout the ranks of those involved in museum activities.

Several months ago we were very pleased to hear from Al Backstrom, AAA M-1697, of Little Elm, Texas, offering to donate his experimental Flying Plank N-20WB to the APM. This unique machine was developed with the help of Van White, a well known experimentor of Lubbock, Texas and another friend John Powell. The Plank first flew in 1975 and on May 2, 1976 the first flight around the pattern was achieved. On the 28th of May extended flight was made outside the airport pattern. Being powered with a two cycle engine there was alot of development work and through trial and error many problems surfaced and were solved. The first engine lasted 71 hours and 30 minutes. After feverish engine repair efforts the Plank was taken to Oshkosh by trailer and was successfully demonstrated there at the 1977 EAA Fly-In.

During 1978 and 1979 further development continued. Al Backstrom decided to attempt a X-C to Oshkosh 1979 but run into more engine problems and time ran out for making Oshkosh that year.

By 1980 a total of 110 hours were logged on the Plank. Al Backstrom has since retired from the FAA. A broken arm suffered in a fall has delayed his efforts to deliver the Plank to the APM.

We do recall being at the Texas AAA Chapter Fly-In at Denton in 1980 when Al flew his Plank in for that event. Our cover photo was taken by Brent Taylor at one of the Denton Fly-Ins.

Al Backstrom plans to trailer the Plank to Antique Airfield and we hope to herald his arrival during the July 2-4 APM Reunion. The Backstrom Flying Plank will be suspended in the main APM hangar. It will be an educational display recognizing the ingenuity of Al Backstrom and his associates in the development of such a unique design. Ref: The February 1980 issue of Sport Aviation has a detailed seven page article on the Backstrom Plank.

The APM is very proud to be chosen as the air museum to display the Plank. Our thanks to Al Backstrom and his associates for adding to the scope of the APM Collection.

RLT

3-Views Courtesy of

EAA "Sport Aviation"

February 1980 Issue

Drawing by Dick Johnson